Small mammal populations have been monitored as part of the Denali LTEM program from its beginning in 1992. One aspect of this agreement is to maintain the small mammal monitoring effort in Rock Creek and other drainages near park headquarters (this aspect of the work is actually paid for by the NPS, via the USGS, to simplify contracting arrangements). The research aspect of this agreement addresses the question of how to sample small mammal populations at larger geographic scales.

The Denali LTEM program has always billed itself as an "integrated" watershed approach. The intent to "integrate" was implied by the arrangement of study effort in the Rock Creek watershed (i.e, the collocation of data collection efforts). However, mechanisms to promote integration of results have not yet been developed, and all reporting thus far has focused on individual study efforts. By 1997, it was clear that integration was not going to occur unless some specific effort was put into it. Thus, one purpose of this agreement is to throw some resources at the "integration" question.

Taken over

---------- Draft 1.2 ----------

Denali Long-term Ecological Monitoring Program

Protocol For Long-term Monitoring Of Small Mammal Populations

2005

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---------- DRAFT 1.2 ----------

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SOP 1 — SOME NECESSARY BACKGROUND

1.1 Brief Project History

As part of the Denali Long-term Ecological Monitoring program (LTEM), small mammals have been monitored in the Rock Creek drainage since 1992. The first expansion of this monitoring program took place in 1995 with additional sampling near Wonder Lake at the western end of the park road (approximately 100 km from Rock Creek). A second expansion occurred in 1997 when three additional watersheds in the Rock Creek area were also sampled. Most recently, and with the hope of increasing our understanding of small mammal spatial dynamics throughout Denali, sampling was again expanded in 2000 to include three new sites in addition to those previously sampled at Rock Creek and Wonder Lake. The new sites are spaced between Rock Creek and Wonder Lake at approximately 25 km intervals (if a crow) and are located within 5 km of the park road. Also in 2000, the small mammal monitoring program went online. The WEB is an ideal medium to concisely and accessibly present a great deal of information: maps, coordinates, pictures, data, reports, etc. Check it out!

Web site: (http://mercury.bio.uaf.edu/~edebevec.staff/denali-sites/index.html)

1.2 Calculating Abundance Using Capture-Recapture

The goal of the small mammal research program is to determine the abundance of study species at each grid within each trapping session. Abundances can then be compared between capture sessions, study sites, and years. This study uses capture-recapture methods and models to estimate abundance. All capture-recapture models follow the same reasoning: if animals are marked and released, the proportion of marked individuals in subsequent capture sessions should be representative of the proportion marked in the entire population. Analyses of data from previous years suggested that 12 capture sessions (3 per day for 4 days) were sufficient to generate precise population estimates.

SOP 2 — BEFORE TRAPPING STARTS

2.1 Field Season Preparations

Ideally, the field crew will arrive in Fairbanks ten days prior to the start of the first trapping session (see Box 2.1). The first three days will be spent in Fairbanks organizing field equipment, acquiring provisions, and examining museum specimens to aid field identifications. The next week will be spent in Denali setting up the trapping grids, hauling traps to the study sites, and networking with the NPS resource staff and bear technicians. Formal training will all be 'hands-on' and will occur during the first week of sampling when the principal investigator (Dr. Eric Rexstad) will be in the field with the crew.

Depending on the vehicle being used, two or three road trips will be required to get all the necessary gear from Fairbanks to Denali. The bulk of the cargo will be traps (~1200) and food for the first half of the season. Check with the LTEM coordinator as to where to store equipment at Denali.

Box 2.1: The First Ten Days

To be done in Fairbanks …

- Complete necessary paperwork to start employment process (see Marta Rm #309)
- View museum specimens (target and non-target species)
- Purchase food from Fred Meyers (for purchase order see Genelle Rm #308)
- Purchase bait from Alaska Feed (2 x 50 lb bag of cracked sunflower seeds)
- Microwave bait to prevent germination (100 lb x 1.5 minutes on high per pound)
- Purchase additional equipment as required (see accompanying checklists)
- Ensure field equipment is functional (particularly palmtops, laptops, and tents)
- Review data handling and downloading procedures with Eric

Upon arrival in Denali …

- Meet with LTEM coordinator
- Pickup road permit (arranged by LTEM coordinator)
- Pickup radio from dispatch (discuss radio protocol with dispatch)
- Watch "Rules of the Road" video, an instructional *and* inspirational video on driving the park road
- Watch "Denali Backcountry Video" at the Visitors Center
- Meet with Bear Technicians
- Get bear barrels (4 large) from Bear Techs or backcountry desk
- Arrange for equipment storage and refrigeration (for mortalities) with LTEM coordinator
- Checkout living arrangements for weekend accommodations

Setting up …

- Five days will be needed to setup grids at all study sites (see section 2.3)
- All 400 traps can be brought to the Rock Creek site as it is the first site trapped
- 150 traps can also be cached at each site at this time

2.2 Field Season Sampling Schedule

Like most biological field seasons, particularly those that must make the most of the short sub-arctic summer, the workload can be described as intense. Have no illusions, this is not a standard 40-hour/week job.

Over the course of the summer, the study sites are each sampled twice except for Rock Creek which is sampled three times. A sampling session involves 12 trap checks, 3 per day for 4 days (Monday thru Thursday). Sundays are for driving to the site, hauling required gear (2 or 3 trips), pitching camp, and setting the traps. Fridays are for packing down camp, hauling gear out of the site (2 or 3 trips), and driving back to Healy. Saturdays are for data processing and food pack-up for the next sampling session (see Box 2.2).

Box 2.2: Sampling Schedules

2000 Seasonal Sampling Schedule:

June 12	Start work
June 18-23	Rock Creek
June 25-30	Teklanika
July 2-7	Wonder Lake
July 9-14	Stony Creek
July 16-21	Polychrome
July 23-28	Rock Creek
July 30-4	Teklanika
August 6-11	Wonder Lake
August 13-18	Stony Creek*
August 20-25	Polychrome
August 27-1	Rock Creek
September 1-4	Cleanup

*snowed out

2000 Weekly Sampling Schedule:

Sun	Mon	Tue	Wed	Thu	Fri	Sat
Pack ALL gear	Trap check 0600	600	600	600	Pack-up camp	Process data
Drive to site	1300	1300	1300	1300	Haul-out gear (x 2)	Pack food
Haul gear (2-3 trips)	2000	2000	2000	2000	Drive to Healy	Dry gear
Setup camp						Laundry
Set traps						

2.3 Initial Grid Setup:

There are four trapping grids at Rock Creek and three trapping grids at all other locations. Each grid covers an area 90 m x 90 m (0.81 hectares) and consists of 100 Sherman live-traps spaced at 10 m intervals. Individual trap locations are marked with flagging tape during the field season. However, to minimize visual impacts, all flagging tape has to be removed at the end of each field season. All trapping grids, therefore, need to be re-established during the first week of each field season (see Box 2.3). To make the most of this first week, 150 traps can also be hauled out to each site (400 to Rock Creek) and then cached until needed.

Box 2.3: Establishing a trapping grid*

1. Use the GPS unit to navigate to one corner of a grid (see Appendix 1 for coordinates)
2. Mark this corner with flagging tape
3. Have a second person use the GPS to navigate to the second corner
4. Distance between these corners should be 90m; adjust using the laser rangefinder[#]
5. Have second person walk towards first flag while the other person 'shoots= the approaching person with the rangefinder
6. Tie flagging to vegetation at 10 m intervals⊥

Now that the baseline is established, the remaining trap locations need to be determined:

7. Have one person use a compass to walk a perpendicular bearing away from each baseline flag in the direction shown on the site maps (Appendix 1)
8. Again the rangefinder is used to determine 10 m intervals; flags are placed at each of these intervals
9. Flag adjacent lines with different colors to help prevent wandering onto the wrong line when checking traps (e.g. 7A-7J orange, 6A-6J blue, 5A-5J orange)
10. Use a sharpie marker to write the correct X and Y coordinates of each trap location (e.g. 5G, 9A) on each flag as shown on the site maps

Summary of equipment needed to setup a trapping grid

- GPS unit
- laser rangefinder
- compass with sighting mirror
- flagging tape (two colors)
- sharpie marker

* it should take 2-3 hours to accurately establish each trapping grid
[#] a simple monocular that displays distance in viewer when button is pushed
⊥ flagging should be visible enough to facilitate trap checking without attracting unnecessary attention
there is ongoing discussion with NPS as to the most appropriate colors for flagging the small mammal grids

SOP 3 — TRAPPING SESSION OVERVIEW

3.1 Getting to the Site (Day 1)

Each trapping session begins with the setting of traps on Sunday evening. Depending on what site you are doing and how many traps need to be hauled to the site, the day will start sometime between 0700 and 1500 (see Box 3.1). For instance, if you are going to the Stony Creek site and you have 160 traps to bring in, the day should begin around 9am: 3 hour drive, 1.5 hour for first haul with personal gear and food, 1 hours to setup camp and eat lunch, 1 hour back out to vehicle, 1.5 hour for second haul out with traps and remaining gear, 1 hour for dinner break, 3-4 hours to setup trapping grids. Traps can be setup anytime after 1830.

Box 3.1: Latest Sunday departure times from headquarters*

Rock Creek	1500
Teklanika	1200
Polychrome	1000
Stony Creek	0900
Wonder Lake	1000

* assuming a two-person crew and 160 traps to be carried out

3.2 Setting Traps (Day 1)

The folding traps used in the small mammal program are manufactured by the H. B. Sherman Company (7.6cm x 8.9cm x 22.9cm). The traps are sufficient to catch the largest individuals studied yet sensitive enough to capture shrews.

Each trap is baited with approximately one tablespoon of cracked sunflower seeds. The seeds have to be microwaved beforehand to further prevent germination (1.5 minutes on high per pound). To minimize thermal stress of the animals, bedding material is also put in each trap in the form of a nestlet, a 6cm x 6cm x 1cm square of compressed cotton. Nestlets are more compact than the commonly used batten and thus easier to carry into the backcountry. Nestlets can be acquired from animal supply stores.

Eric Rexstad (PI) will demonstrate the proper technique for setting traps in the field during the first trapping session. Basically, traps are unfolded until they lock into an upright position. The front door is then pushed all the way open until the trigger catches and locks the door in the open position. The door will close when an animal enters the trap and steps on the treadle in the back of the trap. Depression of the treadle causes the trigger to release the door which then springs closed. Trap tension (how easily a trap will spring) is adjusted by manually manipulating the trigger. Traps should spring when lightly tapped. Additionally, make sure debris (brush, dried feces, soiled nestlets, or bait) doesn't get stuck under the treadle and prevent it from being depressed.

Traps are placed so as to be visible from the trap station flag, usually within 1m. It is important that traps are level and that the opening is not obstructed. Depending on vegetation cover, traps can be partially nestled into vegetation or left exposed.

3.3 Checking Traps (Day 2 to 5)

Monday through Thursday (inclusive) traps are checked three times a day. Three trap checks are the most that can be asked of the field crew while minimizing the time animals spend confined in traps.

The first daily trap check begins at 0600 on Monday morning. This necessitates alarm clocks being set for 0530-0545. It is wise to have both members of the field crew set an alarm clock(s). Depending on the need for a morning energy boost, some crewmembers will desire food (power bar etc.) prior to starting the first check. The morning check is usually the busiest with respect to the number of captures as small mammals tend to be more active overnight and the interval since last trap checks is greatest at this time. Expect to spend up to 4 hours on the morning check depending on the number of captures; if it is an exceptionally busy year it could be longer still (good luck!). At the completion of each check, it is important to organize for the next check: process mortalities, re-supply bait and nestlets, and save the data.

The second daily trap check begins at 1300 hours. Because this is usually the lightest check, additional effort is spent checking the working performance of each trap (see trap maintenance) and re-baiting if necessary. This check should hopefully be done by 1600, just in time for a nap and leisurely meal prior to the last check of the day at 2000.

This day-to day schedule is repeated until the last check of each week at 2000 on Thursday. Late in the season, as the 24 hr light wanes, the evening checks can be started earlier (1930 or so) to ensure completion prior to nightfall. Nonetheless, headlights may be needed to process the last

animals of the evening. During the last trap check of each session (Thurs 2000), the traps are also packed into the trap boxes and cached until the next sampling session or carried out to be used at other field sites. It is important to hide traps as much as possible when caching to prevent tampering and reduce visual impacts. It is even more important to remember the location of the caches (use the GPS to mark all cache locations as flagging has on occasion been removed by 'helpful' backpackers).

3.4 End of the Sampling Week (Day 6)

Depending on the accommodations provided by NPS, the crew will usually remain at the field camp on Thursday night and pack out gear on Friday morning. Because there is not the necessary number of traps required to have a full complement of traps at each site, it will also be necessary to pack-out some traps (usually 160 traps). This makes Friday a reasonably full day unless you are at the more accessible Rock Creek site. If there are accommodations for Thursday night, personal gear can be hauled out Thursday afternoon and the traps can be hauled to the vehicle after the last trap check. This makes Thursday a very long 18+ hour day, but it does provide some facsimile of a weekend. The crew will have to decide what is easier on their sanity.

3.5 "Weekends" (Day 7)

Between Friday afternoon and Sunday morning is the weekend. During this time period several tasks need to be accomplished: compile and email the week's data to Eric (ffear@uaf.edu), pack up food for the next field session, re-supply processing gear, dry equipment, do laundry, and, most importantly, try to recuperate as much as possible (may involve the all-U-can-eat buffet at Lynx Pizza or some inebriants at the Smoke Shack). It might be a good idea to bifurcate the weekend tasks between both crewmembers as much as possible to allow for brief moments of personal time.

SOP 4 — PROCESSING SMALL MAMMALS

4.1 Species Identification

The small mammal monitoring in Denali has focused on three species: the northern red-backed vole (*Clethrionomys (now Myodes) rutilus*), the tundra vole (*Microtus oeconomus*), and the singing vole (*Microtus miurus*). With the expansion of the monitoring to new study sites in 2000, there was some question regarding species distribution, but all three species were found be present at all sites and comprised the great majority of captures. Incidental captures of other small mammals have included northern bog lemmings (*Synaptomys borealis*), shrews (*Sorex sp*.), and in 2000 the first two yellow-cheeked voles (*Microtus xanthognathus*), but demographic data was not collected on these species. Red Squirrels and Arctic Ground Squirrels were modest nuisances, setting off traps and occasionally getting captured.

Compared to southern locales, species identification in depauperate interior Alaska is relatively straightforward. Preliminary training in identification is accomplished via viewing the superb collections at the UAF museum. Detailed training comes via in-hand experience under the guidance of Eric Rexstad (PI) in the first week of the field season. The main difficulty in species identification occurs when trying to differentiate juvenile *M. oeconomus* from juvenile *M. miurus.* Additionally, a dark phase of *C. rutilus* is present in some years and at quick glance it can be mistaken for *M. economus*. Be sure to also examine museum specimens of incidentally captured small mammals (northern bog lemmings and yellow-cheeked voles) and non-target species (shrews, weasels, squirrels, birds, and frogs).

Defining characteristics of *C. rutilus* is the sharpness of the snout, exposure of the ears, and reddish pelage. The length and shape of the tail is the most useful characteristic to differentiate the two *Microtus*: *M. oeconomus* has a long, tapered tail that is dark on top and light below; *M. miurus* has a short, blunt tail. Secondarily, *M. oeconomus* generally has a dark brown pelage whereas *M. miurus* is generally lighter with golden sides. When wet, pelage differences are much less obvious.

4.2 Passive Integrated Transponders (PIT tags)

The use of Passive Integrated Transponders (PIT tags) has greatly simplified the permanent marking small mammals. In fact, PIT tags are now used to mark a wide range of animals: birds, fish, amphibians, reptiles, and many mammals. Their popularity stems from their numerous advantages: ease of use, reduced misidentifications, and quick handling times of recaptures. The

chips are about the size of a grain of rice, encased in glass, weigh 1g, and are available from Biomark (Boise ID) and other suppliers (~ $5/tag).

A 10-second scan with a tag reader of each capture determines whether it is a new individual or a recapture. If new, sterilized PIT tags are inserted subcutaneously between the shoulder blades using a syringe and a 12-gauge needle (see Box 4.1). If the animal is a recapture it can be released without direct handling. This process is less stressful and more efficient than toe clipping, which requires that even recaptures have to be handled extensively to determine identity. Tag scanners also store scanned numbers in memory until these data files can be downloaded on weekends. These data files can then be used to verify tag numbers recorded in the palmtop at time of capture.

4.3 Handling Techniques

All processing techniques will be taught and reviewed by Eric Rexstad (PI) during the first week of sampling. Certainly the best way to become a competent small mammal technician is via lots of supervised ‘hands-on’ processing experience. The following flowchart (Fig. 4.1), step-by-step guide (Box 4.1) and equipment checklist (Box 4.2) should help to elucidate some of what is involved.

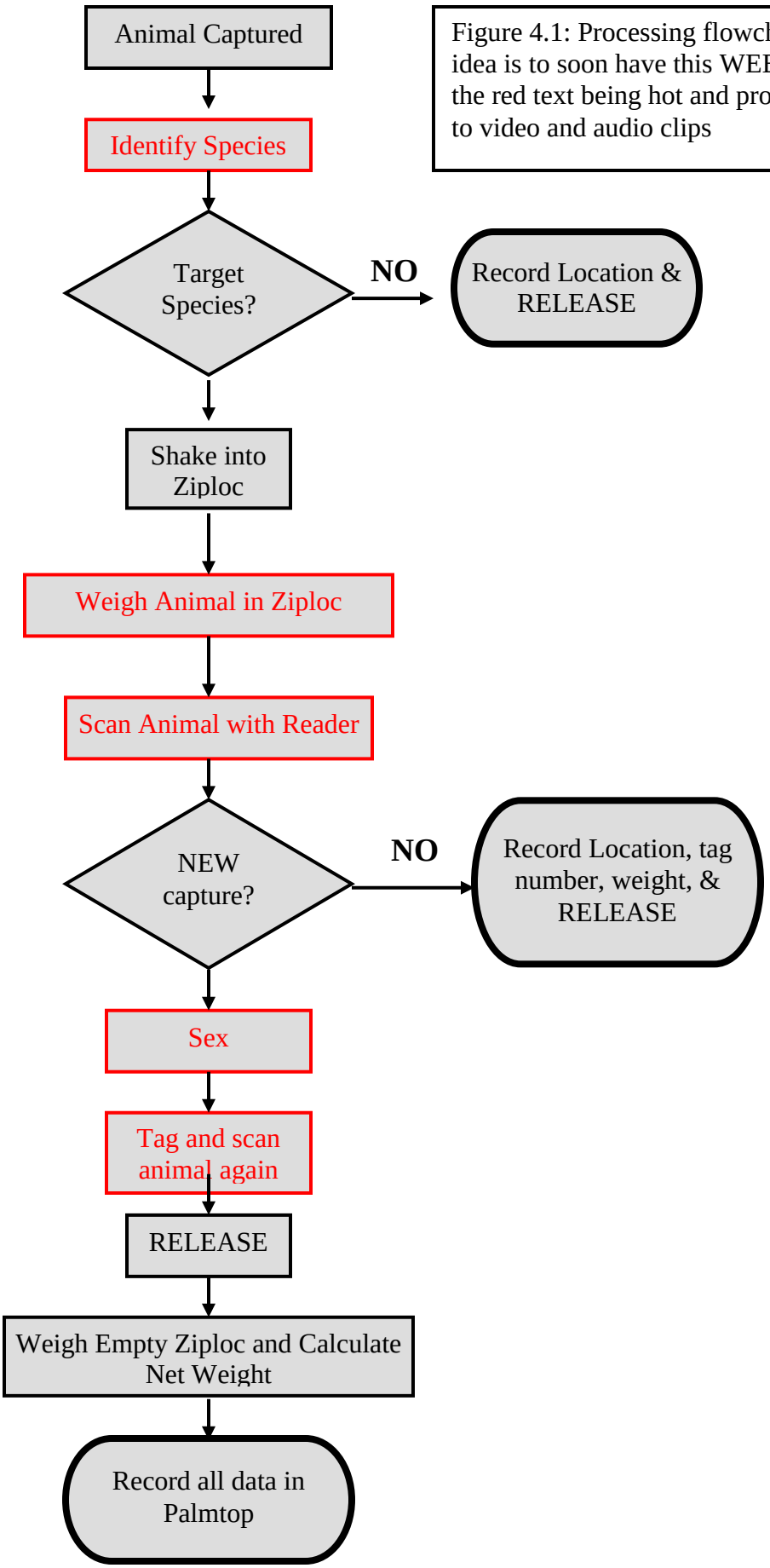


Figure 4.1: Processing flowchart -- the idea is to soon have this WEB based with the red text being hot and providing a link to video and audio clips

Box 4.1: Step-by-step processing guide:

1. Closed traps may indicate successful capture
2. Cautiously open door

3a. If target species then start processing (also process bog lemmings and yellow-cheeked voles)

3b. If non-target species then record trap location, species, and **RELEASE**

3c. If a mortality then place in ziploc and fully label (see Section 4.7)

4. Secure gallon ziploc around trap door
5. Open trap door and shake animal into ziploc
6. Verify species identification
7. Weigh animal while in the ziploc with 100g x 1g Pesola spring scales
8. Scan animal through ziploc with PIT tag reader
9. If no tag is detected then it is a NEW capture and must be fully processed

9a. If a RECAPTURE then record trap location, tag number, weight, and **RELEASE**

10. Coat needle with Iodine
11. Place tag in needle and add another drop of iodine to sterilize tag
12. Add a dab of Betadine to end of needle
13. Scan tag before insertion to ensure it is functioning
14. Grasp animal gently yet firmly through the ziploc
15. Reach into the ziploc and firmly scruff the animal
16. Sex the animal
17. Have a second person insert needle under skin between the shoulder blades
18. Move tag away from injection site with fingers to ensure it doesn't work its way out
19. Re-scan tag number
20. Make sure all data is recorded in Palmtop (see data entry)
21. Release animal
22. Re-weigh empty ziploc and calculate net weight

Box 4.2: Processing Equipment Checklist *

- fly-fishing vests to hold all the processing gear
- gallon size ziplocs to hold small mammals during processing (20 per week)
- sandwich size ziplocs to hold mortalities (carry 100)
- Hewlett Packard Palmtop PC (for recoding data, protected from elements by ziploc)
- spare HP Palmtop
- backup batteries for Palmtop (available from radio shack)
- 100 gram Pesola spring scales (1 per person)
- syringes with sharp needles to insert PIT tags (1 per person)
- PIT tags (bring at least 200 just in case but separate into several film canisters)
- 1 tag reader per person and 1 spare (each takes two 9-volt batteries)
- Sharpie permanent marker
- rite-in-the-rain data book and pencil
- spare batteries (always carry a minimum of eight 9-volts and 4 AAs)
- iodine (to sterilize needle)
- Betadine
- cracked sunflower seeds (2 x 50 lb bag for season; 3 gallon size ziplocs per week)
- nestlets (approximately 800+ per trapping session depending on vole activity)
- 10 spare traps to replace broken or missing traps
- laptop for downloading data from palmtop in the field
- cables and adapters for linking laptop and palmtop
- spare laptop battery
- external 3.5" floppy drive
- floppy discs (to backup data)
- recharge plug will be needed for laptop on weekends
- antibacterial soap for post-work washup
- digital camera and discs to record those special moments
- GPS unit to find plots and mark points as necessary
- compass to setup grids†
- laser-rangefinder to setup grids †
- flagging tape to mark trap locations (two colors) †

* it is necessary to bring into the field spare processing equipment (syringes, iodine, etc.) as they will may go astray on occasion

† equipment for grid setup should be brought incase flagging has be removed

4.6 Trap Maintenance

It is fundamental that traps be in good working order during trapping sessions. Working performance can be impaired due to a variety of reasons: trigger set too tightly, treadle motion impeded by debris (brush, soiled nestlet, or clumped bait), or having a trap that was deformed during transit. It is necessary to thoroughly check the working performance of each trap on a daily basis, usually during the quieter 1300 check. A properly functioning trap should close when lightly tapped and the treadle should move freely when the trigger is manipulated. During these trap checks it is also important to verify the presence of a nestlet and re-bait if necessary. At the end of the season, traps are dismantled, scrubbed, and disinfected in preparation for the next field season.

4.7 Trapping Mortalities

Inevitably, some mortalities result from the trapping process, despite the use of livetraps and three trap checks per day. To make the most of these losses, mortalities are donated to the UAF museum for preservation, dissection, and genetic analyses. In the field, mortalities should be placed in individual sandwich-size Ziplocs immediately after removal from traps. Also placed in the Ziploc is a piece of paper containing all necessary data: species, sex, weight, date, time, trap location, plot, latitude, and longitude. Back at camp the mortalities can be stored in the bear barrels (proper bear storage), or a hole can be dug well away from the tents (100m) and the mortalities can be buried in this cooler location (improper bear storage but better refrigeration). In 2000, mortalities were buried without incident.

SOP 5 — DATA MANAGEMENT AND ANALYSIS

5.1 Data entry

Field data is entered directly into a Hewlett Packard Palmtop PC. Entering data directly into the Palmtop has major advantages: transcription errors and data entry time are both reduced. Disadvantages include the lack of a 'hard' copy of the data and the fragility of the Palmtops. Obviously, it is important to be exceptionally careful with the palmtops – they are designed for the office and not the field. Palmtops are protected from the elements by placing them in a gallon Ziploc and folding the Ziploc to conform to the Palmtop's dimensions and then taping the folds down with duct tape. In the field, data are entered into a LOTUS spreadsheet (see Fig. 5.1).

Date	Hour	Plot	X	Y	Tag Number	N/R	Species	Sex	Weight	Comments
08/21/00	6	RF1	8	A	413905C267	N	CLRU	F	26	LACTATING
08/21/00	6	RF1	6	I			SOSP		4	MORT SHREW
08/21/00	6	RF1	3	B	4142652D23	R	MIMI		46	

Figure 5.1: Three lines of spreadsheet showing data as entered in the field.

5.2 Downloading palmtop to laptop

While in the field, data are transferred from the Palmtop to a laptop on a nightly basis. Data are saved to the hard disk and also to a floppy disk; therefore, at the end of each field day there are three copies of the data. In the case of Palmtop failure, one day's data at most could be lost. The downloading procedure is straightforward and takes maybe fifteen minutes (see Fig 5.2 and Box 5.2). Again, Eric Rexstad (PI) will demonstrate all data handling procedures during the first week.

Figure 5.2: The electronic paraphernalia used to download data from the Palmtop and tag reader in the field.

Box 5.2: Procedure for downloading data file from Palmtop 200LX to Laptop

1. Connect 200LX to laptop via serial cable.
2. Double-click "Direct to COM1" hyperterminal icon on desktop of laptop.
3. From Hyperterminal:
    a. From CALL menu, select CONNECT
    b. From TRANSFER menu, select RECEIVE FILE
    c. Enter directory path and click RECEIVE
4. On 200LX:
    a. Press &... MORE button
    b. Select DataComm and press ENTER
    c. Press MENU key, then File and Send
    d. From here, use TAB and SHIFT+TAB to get desired path and file, then OK
    e. Should see transfer progress on 200LX and in Hyperterminal
    f. When finished, press MENU then QUIT
5. From Hyperterminal:
    a. From CALL menu, select DISCONNECT
    b. From FILE menu, select EXIT

5.3 Summarizing data and creating capture histories

On a weekly basis, the data have to be readied by the crew leader for further analysis by the primary investigator. The cross tab function in Corel's Quattro Pro is used to summarize the data in a format that is simple and easy to read. For our purposes, cross tabs are used to summarize the number of captures at each plot during each sampling session (Fig. 5.3), and also to look at the number of new captures and recaptures during each sampling event (Fig. 5.4).

Date	28-Aug-00			29-Aug-00			30-Aug-00	
Hour	6	13	20	6	13	20	6	13
RF1	9	2	9	11	5	6	14	5
RF2	1	1	1	8	2	4	8	4
RR1	9	6	8	13	6	6	13	9
RR2	14	4	10	17	9	10	20	5
TOTAL	33	13	30	49	22	26	55	23

Figure 5.3: A section of the output generated when using the cross tab function to count the number of captures during each sampling event.

		28-Aug-00			29-Aug-00			TOTAL
		6	13	20	6	13	20	
CLRU	N	20	5	7	14	1		47
	R	6	5	15	25	16	20	87
MIOE	N	2		1	1			4
	R	5	3	5	9	5	6	33
RS				1			1	2
SOSP				1				1
	TOTAL	33	13	30	49	22	26	174

Figure 5.4: A section of the output generated when using the cross tab function to count the number of new captures and recaptures during each sampling event.

The cross tab feature can also be used to create capture histories, a complete record of when each individual was captured throughout the course of each sampling session. Basically, the cross tab function searches for all trapping occasions on which an individual is encountered. If the individual was captured on a particular sampling occasion then a "1" is entered into the spreadsheet, if the animal was not captured then a "0" is entered. The resulting spreadsheet can be imported directly into the program CAPTURE for computation of abundance estimates.

Date	28-Aug-00			29-Aug-00			30-Aug-00	
Hour	6	13	20	6	13	20	6	13
413905223C	1	0	1	1	0	1	0	0
41390B2117	1	0	1	1	0	0	1	1
41390D6F6D	0	0	1	1	0	0	1	0
4139181262	1	0	0	1	0	1	1	1
4139283D51	0	0	1	1	1	1	1	0

Figure 5.5: A partial capture history for five individuals (1 = capture. 0 = absent)

5.5 Calculating abundance estimates using CAPTURE

Estimating abundance by plot and session can be done in a couple different ways. Currently, we use S-PLUS to do all our data analysis, including a call to CAPTURE. Alternatively, one could create individual input data files and run CAPTURE manually.

When a trapping session is complete and the data have been verified, the raw data are imported into S-PLUS. The working data directory is `m:\splus\voles\_Data`, located in the user directory for edebevec.staff on Mercury, the Biology and Wildlife computer network. Attach to this directory using the `attach()` function, or use the `setup()` function and choose the first option: Small Mammal. All data from the Denali LTEM small mammal study are compiled in the data frame *allyears*, currently at 25,895 rows. The 16 data fields are as follows:

Data Field	Description
LOCATION *	Site name (ROCK, TEK, POLY, etc.)
YEAR *	Year data were collected
SESSION *	Session number within year
DATE	Month, day, and year that capture occurred
HOUR	Trap check within day (6=0600, 13=1300, 20=2000)
PLOT	Name of trapping grid or web
X	X label for trap within plot
Y	Y label for trap within plot
TAG	Tag number of individual
TOECLIP	Identifying toeclip used for part of 1992
N.R	New capture (N) or recapture (R)
SPEC	4-character species identification code
SEX	Sex identification (M, F)
WT	Weight in grams
MORT *	Logical value (T=mortality, F=not mortality)
COMMENTS	Additional comments

Figure 5.6: Column names and description for small mammal capture data frame in S-PLUS.

The spreadsheet described in Figure 5.1 is imported into S-PLUS as a new data frame using the Import Data command or by cut and pasting into an empty data sheet. The fields identified above with an asterisk (*) are not included and need to be added with the function `add.data()`. It is important to note that mortalities must be identified by the keyword "MORT" in the COMMENTS field. The letters can be any combination of upper and lower case. The data frame that is output from `add.data()` can be appended onto other data frames (e.g., *allyears* or *denali00*), or kept separate. In the past we accumulated data throughout a field season into a single data frame, and then added the season's data to *allyears* at the end of the season. Be sure to remember to add a column for TOECLIP before appending.

Other data frames within S-PLUS are used to record the dates and times that each plot is checked. The data frame *rock.sessions* lists all trap checks at Rock Creek and the data.frame *other.sessions* lists trap checks at all other sites. The first 4 fields in each data frame are YEAR, SESSION, DATE, and TIME as described above for *allyears*. Each additional field is for a specific plot and consists of a logical response: True if the plot was checked at that date and time, and False if not. These data frames are needed for generating capture histories on those occasions when there were no captures on a plot during a trap check.

These 3 data frames (*allyears*, *rock.sessions*, and *other.sessions*) are used to estimate abundances using CAPTURE. The function `capture.history()` is used to generate capture histories for a given year, plot, session, species, and optionally sex. Common species codes to use are CLRU (*Clethrionomys rutilis*) and MISP (all *Microtus* species). The function `capture.history()` returns a list comprised of the following objects:

Object	Description
call	Repeats the function call
location	Site name
year	Sample year
session	Session number within year
plot	Plot name
spec	Species
sex	Sex (NA if both used)
capture.history	Capture history matrix (1=captured, 0=not captured)
trap.checks	Date and times of all trap checks
is.mort	Logical vector (T=mortality, F=not mortality)

Figure 5.7: Components of a capture history object in S-PLUS.

Once the capture history is generated, it is used with the function `capture()` to call the program CAPTURE to generate the abundance estimate. By default, CAPTURE performs a model selection routine and generates estimates under all possible models. The results of the model selection routine are output to the S-PLUS commands window. The analyst looks over the results and selects a model from the menu. The abundance estimate with standard error and 95% confidence interval for the selected model are then displayed. We record the species, plot name, session number, abundance estimate (N), standard error (SE), confidence interval, model selected, M(t+1), and the number of mortalities. The data frames *rock.estimates* and *other.estimates* contain abundance estimates for Rock Creek and all other sites, respectively.

5.6 Data archival in MS Access

At the end of each field season, data are collected and added to the MS Access database *smdata.mdb*. The database consists of 6 tables and a data query form that allows for filtering the data by year, location, plot, session, and species. Appendix 2 provides a summary of this database. The *Captures* table is the equivalent of the *allyears* data frame in S-PLUS, containing all the individual capture data from all years in the study. All other tables are simple informational tables that give a general description of the locations sampled (*Locations*), detailed locations of every plot (*Plots*), a brief schedule of plots used in each year (*Plots Used*), a listing of session dates and personnel (*Sessions*), and vegetation surveys performed at Rock Creek (*Vegetation*).

To compile the *Captures* table at the end of each field season, perform the following.

(a) In S-PLUS, create a temporary data frame that is the same as the seasonal data frame, except that MORT is now 0 if false, and 1 if true.

```
tmp <- denali00
tmp$MORT <- as.numeric(tmp$MORT)
```

(b) Copy this data frame into an Excel spreadsheet. Add and empty column after TAG for the TOECLIP field. Get the last index number from the *Captures* table in the database. Insert a new first column in the Excel spreadsheet that continues this index for the new data.

(c) Save the spreadsheet as a comma-delimited file without the header row.

(d) From Access with the database open, select File > Get External Data > Import. Select the comma-delimited file just created. Click Next a couple times. When asked "Where would you like to store your data?", select "In an existing table" and choose *Captures*.

The Filter Data query allows you to select a subset of the data in *Captures* for export. You sequentially select items from the choices on the left. Only choices that persist from one level to the next are displayed. For example, the first selection allows your choice of year(s). As with all selections, more than one choice can be made. Click on the year(s) you want, holding down the Control key if selecting more than one. Then click on the right arrow to accept your choice(s). Possible locations are then displayed in the next selection area. Choose the location(s) you are interested in and continue until all 5 selection stages have been completed. Click on the Run Filter button and a new table will be opened containing the requested data. You may select Save As to save this in a file, or you can cut and paste into another application.

5.7 WEB presentation of data

With the 2000 field season, we began posting current information about the small mammal study on a website. We were able to post maps and other site-specific information that the field crew could access even before arriving in Fairbanks and we could publish abundance estimates literally within hours of completing a session. The website homepage is currently at this address:

http://mercury.bio.uaf.edu/~edebevec.staff/denali-sites/index.html

The main page contains a map of Denali National Park and Preserve with the location of our current 5 sampling locations. Moving the mouse over one of the sites will open a small window containing sampling dates for the current field season. Clicking on the site will bring you to a series of maps of increasing resolution that illustrate individual plot locations. Moving the mouse over a plot will open another window containing latitude and longitude coordinates for the corners. Units can be degrees/minutes/seconds or decimal degrees. Click on the Select GPS Units button to choose. This requires writing a file to your local hard drive to specify the desired units, so be sure you allow cookies with your browser. Additionally, there are some photographs that can be viewed to aid in site location in the field.

Below each of the sample sites on the main map, there is an area labeled "View Data". Moving the mouse over these areas will display current plots of abundance estimates for all plots at the site. There is also a link near the bottom of the page that brings you to another page with all abundance estimates in tabular form.

SOP 6 — WORKING IN THE BACKCOUNTRY

6.1 Low-impact Camping

The Denali ecosystem is very fragile. Minimizing unnecessary impacts is an essential aspect of working in the backcountry. Complications arise because trapping small mammals involves camping in one location for 5 days and repeatedly walking the same routes to check the traps. Walking may sound inconsequential, but minor trails can develop in only few passes across tundra. Currently, discussions are still underway with NPS regarding how best to get the work done while minimizing impacts. Regardless, treat the work area as sensitively as you can and

leave as little trace as possible. There is information and expertise available on low-impact camping at the backcountry desk.

Figure 6.1: Obvious Low-impact Suggestions

- pack out everything
- make sure campsites are out of sight of the road
- avoid camping in the exact same location on subsequent visits
- avoid using the exact same routes repeatedly if possible
- camp and cook in spots that can absorb greater impacts
- do not damage vegetation unnecessarily
- do not over-flag grids (amounts used will depend on vegetation cover)
- explain to inquisitive backcountry users what you are doing and why

6.2 Bear Etiquette:

When working in the backcountry of Denali, there will be ample opportunity to view bears in their natural habitat. This is a great privilege but a privilege that necessitates following a number of specific rules (see below). Serious incidents are very rare but as a small mammal researcher, additional care must be taken because some work activities may actually increase the opportunity of having a negative bear encounter. In particular, care must be taken to properly store all bait, mortalities, soiled nestlets, and other garbage in the Bear Resistant Food Containers (BRFCs). This necessitates that extra space be available in your BRFCs as the amount of garbage generated may exceed the amount of food consumed. At Rock Creek, vests and any additional 'smelly' items can be stored directly in the large bear barrel. Because you will be spending more nights in the backcountry than practically anyone else in the Park, it is particularly important not to become complacent with respect to bears and always keep a bear safe camp. To get the full lowdown it is also necessary to schedule a meeting with the Bear Technicians before heading into the field. Additionally, report all unusual bear encounters to the Bear Technicians.

Figure 6.2: Preventing Bear Encounters

- All food and garbage must be stored in special Bear Resistant Food Containers (BRFCs)
- Cook and store food at least 100 yards from tent
- Keep a clean camp
- Watch for fresh tracks and scat
- Avoid surprising bears
- Make other loud noises to warn bears of your presence, especially in dense brush
- Never intentionally approach a bear

If you encounter a bear:

- DO NOT RUN! Running may elicit a chase response from an otherwise non-aggressive bear. Bears can run faster than 30 mph (50 km/hr) – that's faster than you! If the bear is unaware of you, detour quickly and quietly away.

- BACK AWAY SLOWLY if the bear is aware of you but has not acted aggressively. Speak in a low, calm voice while waving your arms slowly above your head. Bears that stand up on their hind legs are not threatening you, but merely trying to identify you.

- SHOULD A BEAR APPROACH OR CHARGE YOU, DO NOT RUN -- DO NOT DROP YOUR PACK ! Bears occasionally make bluff charges, sometimes coming within ten feet of a person before stopping or veering off. Dropping a pack may encourage the bear to approach people for food. STAND STILL until the bear moves away, then slowly back off.

- IF A GRIZZLY MAKES CONTACT WITH YOU, PLAY DEAD. Curl up into a ball with your knees tucked into your stomach, and your hands laced around the back of your neck. Leave your pack on to protect your back.

- IF A BLACK BEAR ATTACKS, fight back vigorously. Do not fight with a grizzly, play dead.

6.3 Necessary Clothing:

The weather of Denali can challenge even experienced backcountry users and necessitates adequate field clothing and gear. Technicians should be prepared for temperatures well below zero, occasional snow at higher elevations, heavy and persistent rain, and rare sunny days with temperatures hypothetically reaching into the nineties.

Figure 6.3: Necessary Clothing (additional personal items will be added to this list) *

- rubberized rain pants (goretex pants are ineffective in wet vegetation)
- goretex jacket and/or rubberized rain jacket
- synthetic long underwear (tops and bottoms – a second set is a good idea)
- fleece jacket (warm layer)
- microfleece (another layer and good to sleep in if everything else is wet)
- synthetic or wool socks (several pairs)
- hiking boots with good ankle support for packing heavy loads
- rubber boots for day to day work in wet conditions (XtraTufs recommended)
- sun hat (when the sun is out it is out for 20 hours a day)
- winter toque
- field pants
- gloves (it is difficult to process animals wearing gloves so expect cold hands)
- mosquito net (for Wonder Lake)

* As in all backcountry camping situations, there are a couple of general rules: 1) layering clothes makes it easier to accommodate variable weather conditions, and 2) cotton is a sponge and provides no warmth when wet (save it for the weekend).

6.4 Camping Equipment

In general, camping equipment is provided by UAF but technicians may wish to use some of their own gear (sleeping bags etc.). It is important to verify that all equipment is in good condition prior to getting into the field. In particular, make sure the tents are seam sealed and if

they look particularly beat-up try to find a replacement. BRFCs are available from the bear technicians or the backcountry desk.

Figure 6.4: Camping Equipment Checklist:

- ❑ Four large bear resistant food containers (BRFCs) (two or three containers sufficed for a two-person crew)
- ❑ tent (ensure seems are sealed / one tent per person is required to avoid bloodshed)
- ❑ sleeping pad
- ❑ sleeping bag (should be rated to around 20E F)
- ❑ tarps (for cooking area and UV protection for tents)
- ❑ backpacks (also used for hauling traps)
- ❑ topographic maps as required
- ❑ stove
- ❑ adequate fuel (will depend on crew size and how many coffees you drink)
- ❑ pot set
- ❑ bowl and utensils
- ❑ mug
- ❑ nalgene water bottles (two per person)
- ❑ water purification system (giardia has been documented in the park)
- ❑ collapsible water buckets (for hauling water to campsite)
- ❑ several lighters
- ❑ headlight and batteries (only needed in last weeks of field season)
- ❑ suntan lotion
- ❑ dish soap and scrubby

SOP 7 — END OF SEASON

7.1 Cleanup

All field supplies must be adequately maintained during the field season, and particular care must be taken at the conclusion of the field season. This includes checking computers, scanners, and Pesolas for proper functioning. All traps have to be dismantled, cleaned, and disinfected. It is also important to make sure that all the data is "put to bed". This includes providing copies of digital photos and backup copies all data files.

7.2 Future Suggestions:

With the completion of each field season, it is very important for the field crew to provide suggestions for the following seasons. This bottom up perspective is imperative. Of course, as is life at the end of a long field season, many of the suggestions will sound like complaints (see below). Of course, as is life when you manage the purse strings, the principal investigator and NPS will nod sympathetically and then disregard many of these suggestions. Also, because these SOPs were just written in Fall 2000, this document should be considered a first draft and any feedback or additions would be much appreciated.

Future Suggestions from the 2000 Field Season (Cam MacDonald and Aren Eddingsaas)

The field season would be much more agreeable if the following suggestions are implemented:

1) Have a full complement of traps for each site

2) Helicopter traps into sites at beginning of year and out of sites at the end of the year (1 - 1.5 hrs of helicopter time on both ends).

These two suggestions, while expensive, would save the field crew a vast amount of work. Hauling traps into field sites every Sunday and out every Friday took a major toll. And when considering the number of person-days spent hauling traps across the tundra, the helicopter really becomes a massive *cost saving* device.

Additionally,

3) Consider changing from 12 trap sessions to 10 or 11 (each session would thus end after the 0600 or 1300 check on Thursday). This would allow the crew to get out of the field at a much more reasonable time on Thursday (1800 hrs).

4) If the above suggestions are not feasible, another layover day should be added to each weekend to allow for modest recuperation and to prevent 'burn-out'.

5) Develop specific criteria for shutting down a trapping session if weather becomes difficult (e.g., 3-inches of snow, overnight temps below 20E F, mortalities > 30% of morning captures).

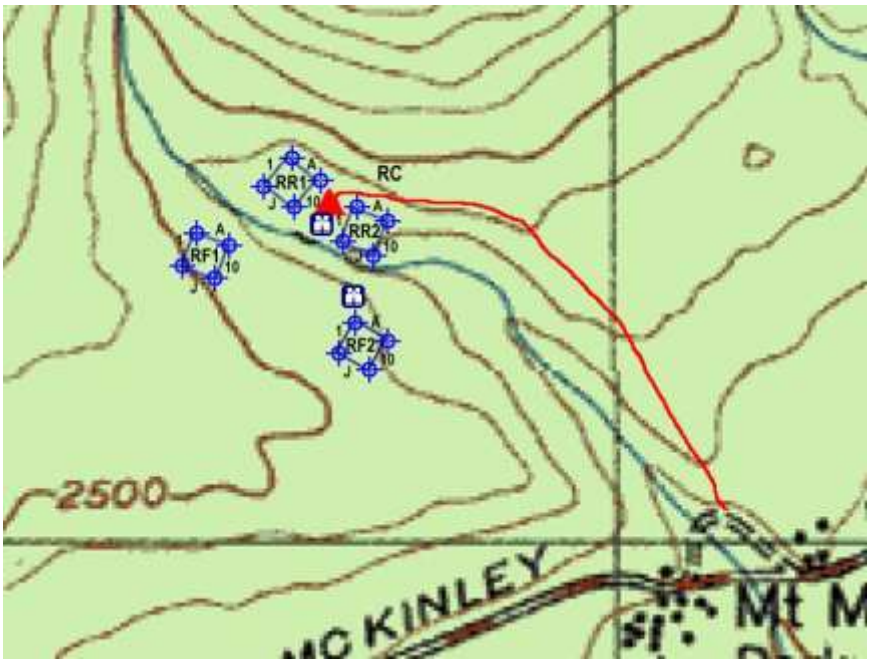
6) In conjunction with NPS, determining flagging protocol and color scheme. This is of particular importance at Polychrome, Tek 3, and Stony.

7) Having an NPS or UAF Vehicle would prevent damage to a personal vehicle on the park road. Mileage is sufficient compensation on paved roads but not necessarily on slow, rough gravel.

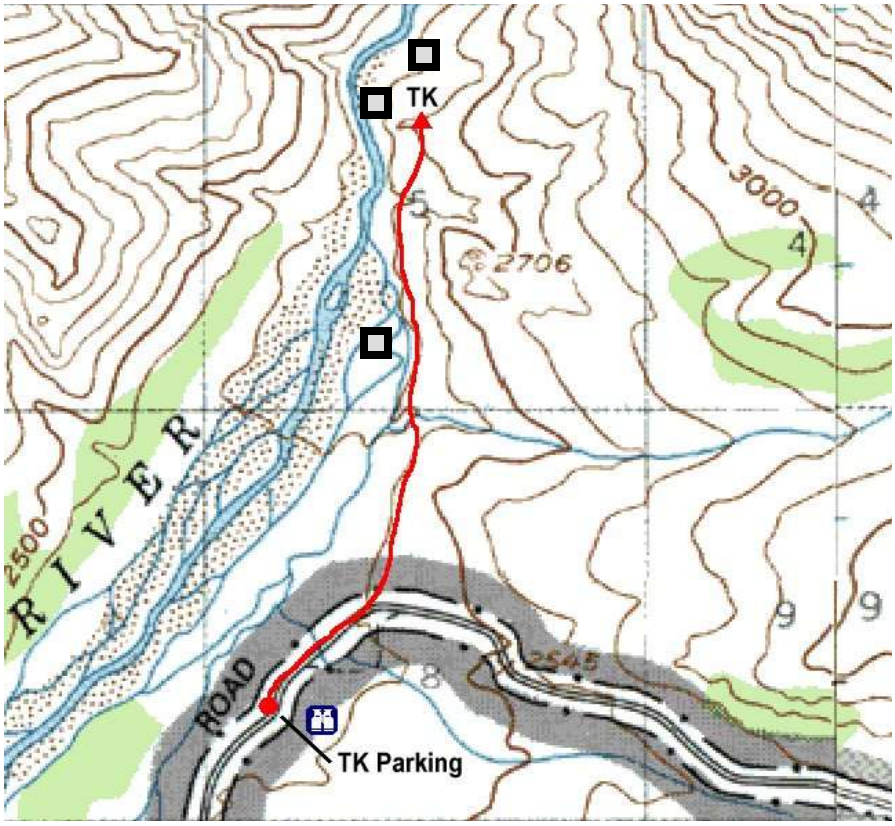
8) A third person on the crew would help with the workload and potentially help with the group "dynamics".

APPENDIX 1: SITE DESCRIPTIONS

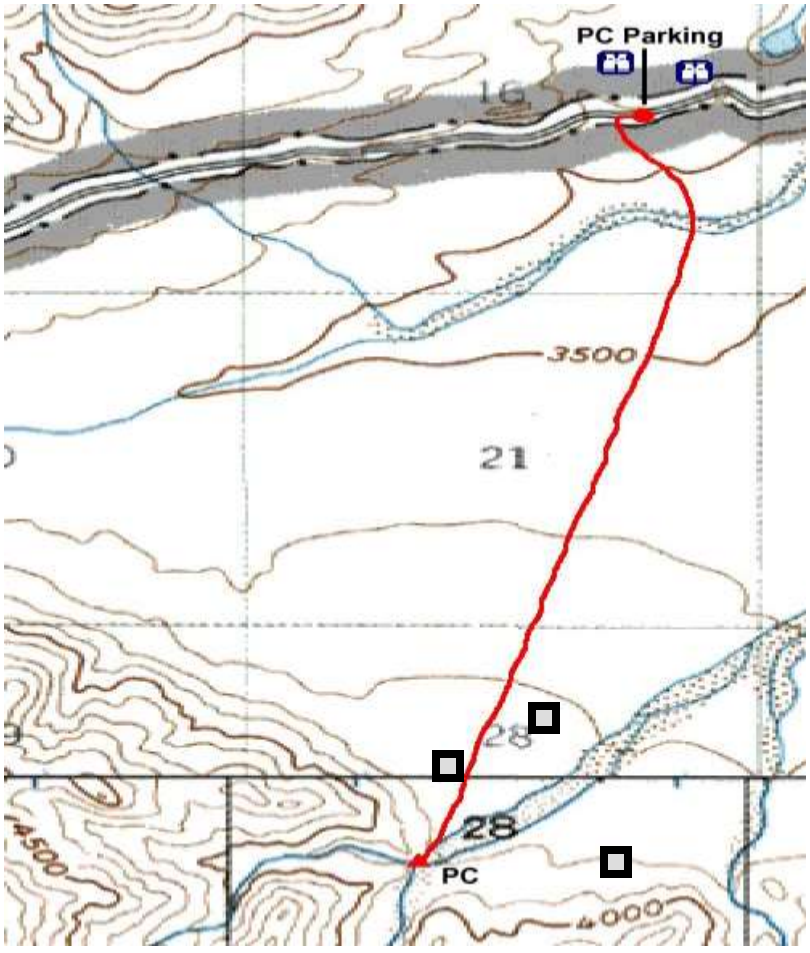
Rock Creek (mile 3 on park road; park at C-camp): The four grids are 1.5 km north of the road at an elevation of 2400 feet. It is an easy 20-minute walk to the site when following a trail that follows the east ridge above Rock Creek. Two of the grids (RR1 and RR2) are riparian and the other two (RF1 and RF2) are on the west ridge above Rock Creek. Habitat is spruce taiga with ground vegetation including a mix of willows, grasses, sphagnum, dwarf birch, and various berries. Because the site has been used for ten years, there are trails between trap sites that are unsightly but facilitate trap checks. A large bear barrel (55 gallon drum) at the campsite simplifies proper storage.



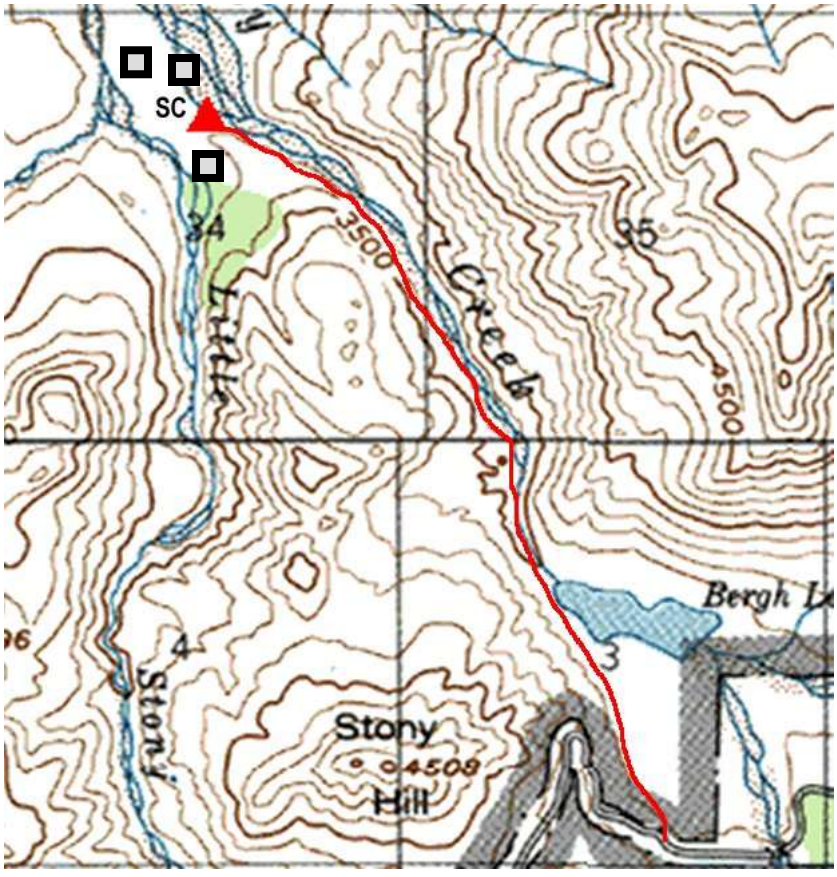
Teklanika (mile 26; park in pullout): The three grids are located on the eastern side of the Teklanika River and are up to 2.5 km north of the road at an elevation of 2600 feet. It is a 45-minute traverse across scrubby tundra and numerous streams to reach the campsite. One grid (TK3) is 15-20 minute walk south of the other two grids and this must be negotiated 6 times a day when checking traps. Habitat for TK1 and TK2 is a mix of open meadow and spruce taiga. TK3 is on a large river bar and is a mix of willow and scrubby grasses.



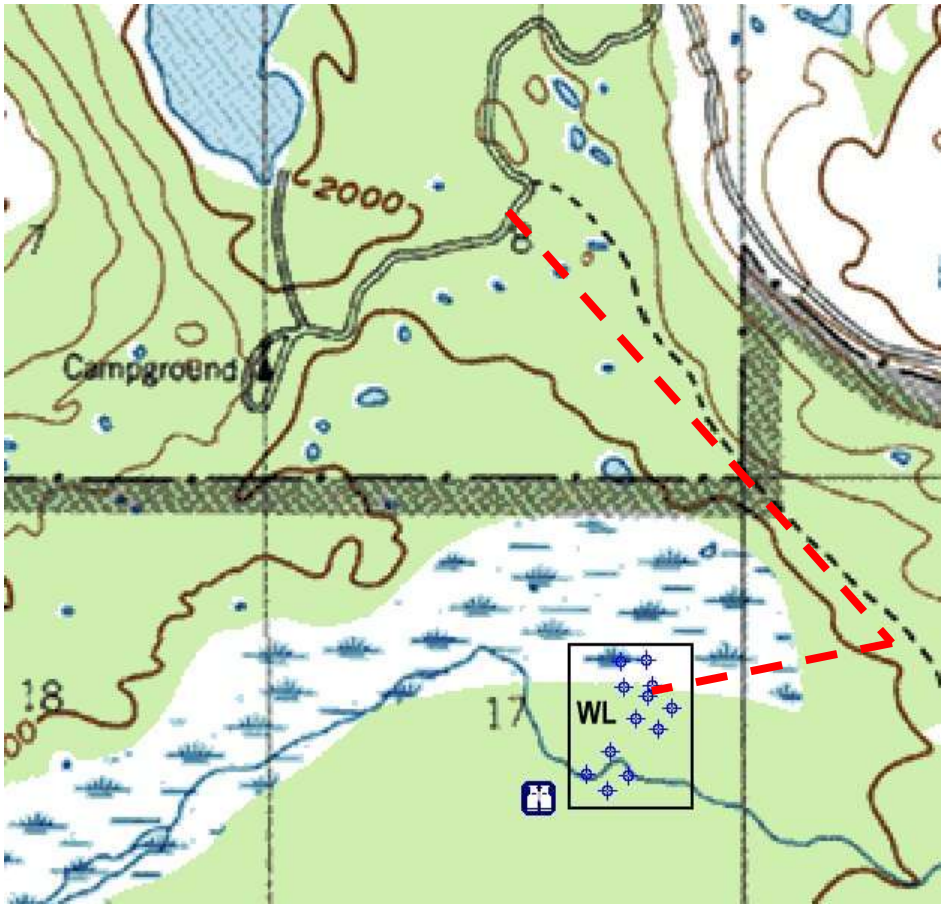
Polychrome (mile 47.7; park in grader parking space on north side of road): The three grids are located 4 km south of the highway, on the far side of the Plains of Murie and at an elevation of 4000 feet. It is a good hour hike to the site. The best route is to thwack east across the plains towards the river where the walking is easier. Two grids (PC1 and PC2) are on the west side of the river and are typical alpine tundra: a scrubby mix of willows, dwarf birch, and grasses. The third grid (PC3) is across the river and is primarily a grassy meadow, wet on the north side. Crossing the river is generally easy in rubber boots, but the flow is very ephemeral and heavy rains can make the crossing hazardous or even impossible. Additionally, the elevation makes frost or snow possible at any time of the year. The best out-of-sight campsite is tucked into a narrow canyon that cuts west into the mountains.



Stony Creek (mile 65?: park in pullout just west of where Stony Creek crosses the highway): The grids are located 4 km north of the highway, near the confluence of Stony Creek and Little Stony Creek and at an elevation of 3500 feet. It is up to an hour and a half hike to the site with gear. The easiest and flattest route is along the river bar. However, as at Polychrome, the river is ephemeral and the bar can be beneath five feet of water if it has been raining heavily. The alternate route is taking the higher, hillier route along the river and then cutting over a ridge to the campsite. The weather can also be detrimental if 2000 is representative; the site seems to catch rain clouds sweeping across the interior and if it is cold then expect snow. Habitat is scrubby alpine tundra and quite uniform for all three grids.



Wonder Lake (mile 85; park McKinley Bar trailhead): The three grids are located 2.0km down the McKinley Bar Trail at an elevation of 2000 feet. It is a 20-minute walk to the grids that are only 100m off the trail. The habitat is spruce taiga / muskeg swamp. The mosquitoes are *awesome* in July — bring your head net, repellent, psychiatrist, etc. As well, take extra care to hide your tent at this site to avoid being visible from the park road and trail.



APPENDIX 2: S-PLUS FUNCTIONS

add.data

DESCRIPTION

Takes raw capture data from field spreadsheet and adds required data columns and makes necessary format changes.

USAGE

```
add.data(df, location, year, session, data=denali00)
```

REQUIRED ARGUMENTS

`df` data frame containing capture data from the field Lotus spreadsheet. This data frame must have the following fields: DATE, HOUR, PLOT, X, Y, N.R, TAG, SPEC, SEX, WT, and COMMENTS.

`location` character string giving the name of the location to be filled in (e.g. "`ROCK`" or "`POLY`").

`year` numeric value for the year.

`session` numeric value for the session.

OPTIONAL ARGUMENTS

`data` seasonal data frame. This data frame is only used as a reference to get the proper order for the columns.

VALUE

The returned data frame has the following columns added: LOCATION, YEAR, SESSION, and MORT.

DETAILS

This operation is to be performed on data from each sampling session.

EXAMPLES

```
> # Look at a few rows of the input data frame:
> DS6[1:5,]
      DATE HOUR PLOT  X Y N.R        TAG SPEC SEX WT  COMMENTS
2 07/17/00    6  PC2 10 F   N NOT TAGGED MIMI   M 13 MORT JUVE
3 07/17/00    6  PC2  6 F   N 41423C760C MIMI   M 32  NONSCROT
4 07/17/00    6  PC2  4 A   N 41422E4759 CLRU   M 14  NONSCROT
5 07/17/00    6  PC2  9 A   N NOT TAGGED MIMI   M 14 MORT JUVE
6 07/17/00   13  PC2  9 C                ARGS

> # Now run the function:
> sc1_add.data(DS6,"STONY",2000,1)

> # Look at a few rows of the resulting data frame:
> sc1[1:5,]
  LOCATION YEAR SESSION     DATE HOUR PLOT  X Y        TAG N.R SPEC SEX WT MORT  COMMENTS
2    STONY 2000       1 07/17/00    6  PC2 10 F NOT TAGGED   N MIMI   M 13    T MORT JUVE
3    STONY 2000       1 07/17/00    6  PC2  6 F 41423C760C   N MIMI   M 32    F  NONSCROT
4    STONY 2000       1 07/17/00    6  PC2  4 A 41422E4759   N CLRU   M 14    F  NONSCROT
5    STONY 2000       1 07/17/00    6  PC2  9 A NOT TAGGED   N MIMI   M 14    T MORT JUVE
6    STONY 2000       1 07/17/00   13  PC2  9 C                ARGS           F
```

capture.history

DESCRIPTION

Returns a list that describes the capture history based on the chosen input arguments. The output can be used as input to the function `capture`.

USAGE

```
capture.history(year, sess, plot, spec, sex, loc, df=allyears)
```

REQUIRED ARGUMENTS

`df` data frame containing capture data. This data frame must have certain fields that correspond to the selection criteria. Required fields are LOCATION, YEAR, SESSION, DATE, HOUR, PLOT, TAG, SPEC, SEX, MORT and are described more fully below. Other fields likely to be included are X, Y, N.R, WT, and COMMENTS.

OPTIONAL ARGUMENTS

`year` vector of year(s) to be used to create the capture history. Can be entered as numeric or character and must be in the same format as `df$YEAR`, currently 4 digits (1998).

`sess` vector of session(s) to be used in the capture history. Can be entered as numeric or character.

`plot` vector of plot(s) to be used in the capture history. Must be entered as character. Can be lower or upper case.

`spec` vector of species(s) for the capture history. Must be entered as character. If `"MISP"` is given, then it is converted to `c("MIOE","MIMI","MISP")`. Can be lower or upper case.

`sex` vector of sex(es) for the capture history. Must be `"M"` or `"F"`.

`loc` vector of location(s) for the capture history. Must be entered as character. Possible locations are `"ROCK"`, `"HINES"`, `"CLARK"`, `"KIKI"`, or `"WONDER"`.

VALUE

The returned capture history object is a list with ten named elements.

`call` a listing of the command line call used to create the capture history. This is for reference.

`location` character string for location (e.g. "`ROCK`" or "`POLY`")

`year` numeric year

`session` numeric session

`plot` character string for plot name(s)

`spec` character string for species

`sex` character string for sex

`capture.history` a column vector with an element for each individual captured as determined by the selection criteria. Each entry is a character string of 1s and 0s that correspond to capture and not captured, respectively. The number of characters in the string is equal to the number of trap checks as determined by the selection criteria.

`trap.checks` a vector with names for the trap-check occasions. The length of `trap.check` equals the number of characters in the `capture.history` elements.

`is.mort` a logical vector whose length equals the number of rows in `capture.history`, corresponding to each individual captured. Value is TRUE if the individual was a mortality and FALSE if not.

DETAILS

The following fields must be present in `df` and have the same spelling and capitalization in their names.

`LOCATION` sampling location (`"ROCK"`, `"HINES"`, `"CLARK"`, `"KIKI"`, `"WONDER"`, `"TEK"`, `"POLY"`, or `"STONY"`).

`YEAR` sampling year, with 4 digits (e.g. 1998).

`SESSION` sampling session. Sampling sessions for each year and each plot are numbered from 1 to the number of sessions. This means there is no connection between session 1 at one location and session 1 at another.

`DATE` sampling date in numeric format as imported from MS Excel. Can convert to other date formats using the function `dates` with `origin=c(12,30,1899)`.

`HOUR` sampling hour of the day. This is almost exclusively 6 (6:00AM), 13 (1:00PM), or 20 (8:00PM).

`PLOT` plot name. Note that the plot names uniquely identify the location, but it is useful to have both fields.

`TAG` tag number.

`SPEC` species code.

`SEX` male or female.

`MORT` logical field. TRUE if the individual died.

When the function is run, text is output to the command window giving the total number of individuals captured and the total number of mortalities.

EXAMPLES

```
> # get capture history for clethrionomys in 1998, session 5,
> # at RF1. Note location of ROCK is implied by plot name and
> # no selection is made based on sex.
> c5rf1.98 <- capture.history(1998,5,"rf1","clru")
7 Total      1 Morts
> c5rf1.98
$call:
capture.history(year = 1998, sess = 5, plot = "rf1", spec = "clru")

$location:
[1] "ROCK"

$year:
[1] 1998

$session:
[1] 5

$plot:
[1] "RF1"

$spec:
```

```
[1] "CLRU"

$sex:
[1] "NA"

$capture.history:
                     [,1]
4111235C55 "000111111111"
411179304E "000111110110"
413A15565D "000000001000"
413A223417 "000001100110"
413A2C6F7D "000100000000"
413A38533C "000111111111"
413A474D18 "010100110000"

$trap.checks:
 [1] "08/31-06" "08/31-13" "08/31-20" "09/01-06" "09/01-13" "09/01-20" "09/02-06"
 [8] "09/02-13" "09/02-20" "09/03-06" "09/03-13" "09/03-20"

$is.mort:
[1] F F F F F F T
```

capture

DESCRIPTION

Creates an ASCII input file from the input capture history, runs the program CAPTURE.EXE, and displays selected results.

USAGE

```
capture(cap.hist, title, infile, outfile, path,
exepath="c:\\capture", remove.morts=T, remove.zeros=F,
remove.unknowns=F, record=NULL, only.once=F)
```

REQUIRED ARGUMENTS

`cap.hist` capture history object as created by a call to the function `capture.history`.

OPTIONAL ARGUMENTS

`title` a title to be printed in the CAPTURE output file. If missing, "Untitled Capture Analysis" is used.

`infile` root filename for the CAPTURE input file to be created. The extension `.inp` will be appended. If missing, the name of `cap.hist` will be used.

`outfile` root filename for the CAPTURE output file. The extension `.out` will be appended. If missing, the same root filename as `infile` will be used.

`exepath` path for the CAPTURE executable file.

`path` path for `infile` and `outfile`. If missing, `exepath` will be used.

`remove.morts` logical. If TRUE, mortalities as identified in `cap.hist$is.mort` will be removed from the capture history. The number of mortalities removed will be printed prior to any abundance estimates in the output.

`remove.zeros` logical. If TRUE, trap checks where no individual were captured are removed.

`remove.unknowns` logical. If `capture.history` encounters individuals with missing tag numbers, tag values of "unknown1", "unknown2", etc., are generated. If `remove.unknowns` is TRUE, then these individuals are removed from the analysis.

`record` name for S-PLUS data frame object to be created or appended to with selected results from a CAPTURE analysis.

`only.once` logical. If TRUE, results from only one model will be displayed. Used to save time when the user simply wants to view the model results selected as appropriate by CAPTURE.

SIDE-EFFECTS

A text file is created by S-PLUS and saved in `path`. The program CAPTURE.EXE is run and generates an output text file that is saved in the same directory.

VALUE

Results from CAPTURE are displayed on the screen. If a name is given for `record`, then selected results will be appended to an existing data frame of that name or to a new data frame with that name. The data frame contains the following fields:

LOCATION, YEAR, SESSION, PLOT, SPEC, SEX, NMORTS, REM.MORTS, UNKNOWN, REM.UNKNOWN, REM.ZEROS, N, SE, LO95, HI95, M, MODEL

DETAILS

The input file for CAPTURE is automatically generated and run. CAPTURE performs three tasks: (1) closure test, (2) model selection, and (3) estimation using all models. When completed, summary statistics are displayed along with results from the closure test and model selection. A menu is then displayed where the user can select a model for which results will be displayed. The nine possible models are M(o), M(h), M(b), M(t), M(bh), M(th), M(tb), Chao's M(t), and Chao's M(h). The results for the selected model are displayed and the menu again appears. The user quits the function by selecting 0 at the menu. If `only.once` is set to TRUE, then the user can only select a single model for viewing. This is useful if the user always wants to only view results for the "appropriate" model, saving keystrokes if several analyses are to be run consecutively.

EXAMPLES

```
> capture(c5rf1.98,"1998 Clethrionomys RF1 Session 5","c5rf198")
From output file c:\capture\c5rf198.out
*** Mortalities removed ***
Summary of captures read
          Number of trapping occasions        12
          Number of animals captured           6
Test for closure
          z-value                             -3.302
          Probability of a smaller value      0.00048

Model selection procedure
Occasion          j=     1    2    3    4    5    6    7    8    9   10   11   12
Animals caught  n(j)=     0    0    0    4    3    4    4    3    3    4    4    2
Total caught    M(j)=     0    0    0    0    4    4    5    5    5    6    6    6
6
Newly caught    u(j)=     0    0    0    4    0    1    0    0    1    0    0    0
Frequencies     f(j)=     2    0    0    1    0    0    1    0    2    0    0    0

Test for heterogeneity of trapping probabilities in population.
               M(o) vs M(h)   Expected values too small. Test not performed.
Test for behavioral response after initial capture.
               M(o) vs M(b)   X^2 = 9.037   df = 1   p = 0.00265
Test for time specific variation in trapping probabilities.
               M(o) vs M(t)   X^2 = 3.115   df = 11   p = 0.98911
Goodness of fit test of model  M(h)
           M(h) vs not M(h)   X^2 = 28.538   df = 11   p = 0.00268
Goodness of fit test of model  M(b)
           M(b) vs not M(b)   X^2 = 26.173   df = 9   p = 0.00192
     Contribution of first capture homogeneity across time
              X^2 = 21.735   df = 2   p = 2e-005
     Contribution of recapture homogeneity across time
              X^2 = 4.438   df = 7   p = 0.72814
Goodness of fit test of model  M(t)
           M(t) vs not M(t)   Expected values too small. Test not performed.
Test for behavioral response in presence of heterogeneity.
              M(h) vs M(bh)   Expected values too small. Test not performed.

Model selection criteria.  Model selected has maximum value.
Model     M(o)     M(h)     M(b)     M(bh)    M(t)     M(th)    M(tb)   M(tbh)
Criteria  0.95     1.00     0.75     0.75     0.00     0.41     0.92     0.77

Appropriate model probably is  M(h)
Suggested estimator is jackknife.

Select a model for viewing (0 to quit):
1: M(o)
```

```
2: M(h)
3: M(b)
4: M(t)
5: M(bh)
6: M(th)
7: M(tb)
8: M(t) Chao
9: M(h) Chao
Selection: 2
***** Mortalities removed. Add 1 to all estimates. *****
Population estimation with variable probability of capture by animal.
See model M(h) of the Monograph for details.
Number of trapping occasions was           12
Number of animals captured, M(t+1), was     6
Total number of captures, n., was          31
Frequencies of capture, f(i)
   i=   1   2   3   4   5  6  7  8  9 10 11 12
f(i)=   2   0   0   1   0  0  1  0  2  0  0  0
          Computed jackknife coefficients
          N(1)      N(2)      N(3)      N(4)      N(5)
     1  1.917     2.750     3.500     4.167     4.750
     2  1.000     0.242    -1.053    -2.689    -4.492
     3  1.000     1.000     1.552     2.867     4.909
     4  1.000     1.000     1.000     0.655    -0.344
     5  1.000     1.000     1.000     1.000     1.177
          The results of the jackknife computations
  i       N(i)    SE(i)     .95 Conf. Limits      Test of N(i+1) vs. N(i)
  0       6                                         Chi-square (1 d.f.)
  1       7.8      1.87       4.2      11.5          2.500
  2       9.5      3.10       3.4      15.6          2.500
  3      11.0      4.18       2.8      19.2          0.964
  4      12.0      5.11       2.0      22.0          0.014
  5      12.2      6.01       0.4      23.9          0.000
The data are ill-conditioned.  As a best guess, use
Average p-hat = 0.3229
Interpolated population estimate is          8 with standard error     2.4922
Approximate 95 percent confidence interval         6 to         19
Histogram of f(i)
Frequency      2    0    0    1    0    0    1    0    2    0    0    0
--------------------------------------------------------------------------------
       2       *                                        *
       1       *              *              *         *
--------------------------------------------------------------------------------

Select a model for viewing (0 to quit):
1: M(o)
2: M(h)
3: M(b)
4: M(t)
5: M(bh)
6: M(th)
7: M(tb)
8: M(t) Chao
9: M(h) Chao
Selection: 0
>
```

APPENDIX 3: SMALL MAMMAL DATABASE

Filename:	smdata.mdb
Format:	MS Access 97
Tables:	captures locations plots plots used sessions vegetation
Queries:	Get Data Unique Locations Unique Plots Unique Sessions Unique Years Unique Species
Forms:	Filter Data Filter Help

TABLES

captures	25,895 rows
ID	Sequential identifier for this table (primary key).
LOCATION	Identifiers used for monitored watersheds (ROCK, CLARK, KIKI, HINES, WONDER, TEK, POLY, and STONY).
YEAR	Year of monitoring
SESSION	Identifier for primary sampling events at each location.
DATE	Date of sampling.
HOUR	Hour of day when sampling occurred.
PLOT	Identifier for plots used (e.g., RF1, RR1)
X	Row identifier for traps in grids or radial identifier for traps in webs.
Y	Column identifier for traps in grids or spoke identifier for traps in webs.
TAG	Unique mark applied to each animal (PIT tag number).
TOECLIP	Toeclip identifier applied to some animals in 1992.
STATUS	New capture (N) or recapture (R)
SPEC	Species of animal captured.
SEX	Sex of animal captured.
WT	Weight of animal captured.
MORT	Identifies whether the animal died (True/False)
COMMENTS	Comments entered by field crew.

locations	5 rows
ID	Sequential identifier for this table (primary key).
LOCATION	Identifiers used for monitored watersheds (ROCK, CLARK, KIKI, HINES, WONDER, TEK, POLY, and STONY).
WATERSHED	Actual name or description of monitored watersheds.
DESCRIPTION	Specifics of how to get to the monitoring sites.

plots	24 rows
ID	Sequential identifier for this table (primary key).
LOCATION	Identifiers used for monitored watersheds (ROCK, CLARK, KIKI, HINES, WONDER, TEK, POLY, and STONY).
PLOT	Identifier for plots used (e.g., RF1, RR1)
DESCRIPTOR	General habitat type (riparian or forest)
SHAPE	Shape of plot. Grids can be squares or rectangles, webs are circles.
MIN X	Minimum X used in trap locations (always 1).
MAX X	Maximum X used in trap locations (10 for grids, 6 for rectanges, 16 for circles).
MIN Y	Minimum Y used in trap locations (always A).
MAX Y	Maximum Y used in trap locations (J for grids and circles, P for rectangles).
# TRAPS	Total number of traps in the plot (100 for grids, 96 for rectangles, and 166 for circles).
NE TRAP	Label for trap in NE corner of a grid.
NE LONG	Longitude of NE corner of a grid.
NE LAT	Latitude of NE corner of a grid.
SE TRAP	Label for trap in SE corner of a grid.
SE LONG	Longitude of SE corner of a grid.
SE LAT	Latitude of SE corner of a grid.
SW TRAP	Label for trap in SW corner of a grid.
SE LONG	Longitude of SW corner of a grid.
SW LAT	Latitude of SW corner of a grid.
NW TRAP	Label for trap in NW corner of a grid.
NW LONG	Longitude of NW corner of a grid.
NW LAT	Latitude of NW corner of a grid.
CENTER TRAP	Label for trap in center of a web.
CENTER LONG	Longitude of center of a web.
CENTER LAT	Latitude of center of a web.

plots used	8 rows
ID	Sequential identifier for this table (primary key).
YEAR	Year of monitoring.

FU	Sampling done on plot FU (True/False)
RF1	Sampling done on plot RF1 (True/False)
RF2	Sampling done on plot RF2 (True/False)
RR1	Sampling done on plot RR1 (True/False)
RR2	Sampling done on plot RR2 (True/False)
FWE	Sampling done on plot FWE (True/False)
FWW	Sampling done on plot FWW (True/False)
RW	Sampling done on plot RW (True/False)
CF1	Sampling done on plot CF1 (True/False)
CF2	Sampling done on plot CF2 (True/False)
NCF2	Sampling done on plot NCF2 (True/False)
CR1	Sampling done on plot CR1 (True/False)
CR2	Sampling done on plot CR2 (True/False)
HF1	Sampling done on plot HF1 (True/False)
HF2	Sampling done on plot HF2 (True/False)
HR1	Sampling done on plot HR1 (True/False)
HR2	Sampling done on plot HR2 (True/False)
KF1	Sampling done on plot KF1 (True/False)
KF2	Sampling done on plot KF2 (True/False)
KR1	Sampling done on plot KR1 (True/False)
KR2	Sampling done on plot KR2 (True/False)
WL	Sampling done on plot WL (True/False)
WL1	Sampling done on plot WL1 (True/False)
WL2	Sampling done on plot WL2 (True/False)
WL3	Sampling done on plot WL3 (True/False)
TK1	Sampling done on plot TK1 (True/False)
TK2	Sampling done on plot TK2 (True/False)
TK3	Sampling done on plot TK3 (True/False)
PC1	Sampling done on plot PC1 (True/False)
PC2	Sampling done on plot PC2 (True/False)
PC3	Sampling done on plot PC3 (True/False)
SC1	Sampling done on plot SC1 (True/False)
SC2	Sampling done on plot SC2 (True/False)
SC3	Sampling done on plot SC3 (True/False)

sessions	53 rows
ID	Sequential identifier for this table (primary key).
YEAR	Year of monitoring.
LOCATION	Identifiers used for monitored watersheds (ROCK, CLARK, KIKI, HINES, WONDER, TEK, POLY, and STONY).
SESSION	Identifier for primary sampling events at each location.
START	Start date for each session.
END	End date for each session.
PERSONNEL	Field personnel for each session.

vegetation	72 rows
ID	Sequential identifier for this table (primary key).
PLOT	Identifier for plots used (e.g., RF1, RR1)
YEAR	Year of monitoring.
TRANSECT	Identifier for each 20 m transect in a plot.
LAYER	Identifies understory (UNDER) or overstory (OVER)
0CM	Vegetation at start of transect.
50CM	Vegetation at 50 cm along transect.
100CM	Vegetation at 100 cm along transect.
150CM	Vegetation at 150 cm along transect.
200CM	Vegetation at 200 cm along transect.
250CM	Vegetation at 250 cm along transect.
300CM	Vegetation at 300 cm along transect.
350CM	Vegetation at 350 cm along transect.
400CM	Vegetation at 400 cm along transect.
450CM	Vegetation at 450 cm along transect.
500CM	Vegetation at 500 cm along transect.
550CM	Vegetation at 550 cm along transect.
600CM	Vegetation at 600 cm along transect.
650CM	Vegetation at 650 cm along transect.
700CM	Vegetation at 700 cm along transect.
750CM	Vegetation at 750 cm along transect.
800CM	Vegetation at 800 cm along transect.
850CM	Vegetation at 850 cm along transect.
900CM	Vegetation at 900 cm along transect.
950CM	Vegetation at 950 cm along transect.
1000CM	Vegetation at 1000 cm along transect.
1050CM	Vegetation at 1050 cm along transect.
1100CM	Vegetation at 1100 cm along transect.
1150CM	Vegetation at 1150 cm along transect.
1200CM	Vegetation at 1200 cm along transect.
1250CM	Vegetation at 1250 cm along transect.
1300CM	Vegetation at 1300 cm along transect.
1350CM	Vegetation at 1350 cm along transect.
1400CM	Vegetation at 1400 cm along transect.
1450CM	Vegetation at 1450 cm along transect.
1500CM	Vegetation at 1500 cm along transect.
1550CM	Vegetation at 1550 cm along transect.
1600CM	Vegetation at 1600 cm along transect.
1650CM	Vegetation at 1650 cm along transect.
1700CM	Vegetation at 1700 cm along transect.
1750CM	Vegetation at 1750 cm along transect.
1800CM	Vegetation at 1800 cm along transect.
1850CM	Vegetation at 1850 cm along transect.

1900CM	Vegetation at 1900 cm along transect.
1950CM	Vegetation at 1950 cm along transect.
2000CM	Vegetation at 2000 cm along transect.

Queries

Get Data	Query designed for use with the Filter Data form.
Unique Locations	Query designed for use with the Filter Data form.
Unique Plots	Query designed for use with the Filter Data form.
Unique Sessions	Query designed for use with the Filter Data form.
Unique Years	Query designed for use with the Filter Data form.
Unique Species	Query designed for use with the Filter Data form.

Forms

Filter Data	Used to filter capture data by year, location, plot, session, and species.
Filter Help	Instructions for using Filter Data. Used separately or from Filter Data form.